A NOTE ON LIGHTNING STRIKES TO AIRCRAFT

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ABSTRACT

A DC-6 research aircraft was struck by lightning on three occasions during a thunderstorm research project at Flagstaff, Ariz., in July 1967. Electric fields and meteorological parameters were measured and recorded.

Similar conditions existed at the time of the lightning strikes. Each event occurred in a dissipating cumulonimbus, near the freezing level and in a region containing both ice and water. Corona discharge from the aircraft occurred prior to each strike.

The possibility exists that one or more of the lightning strikes were triggered by the aircraft.

1. INTRODUCTION

A four-engine aircraft operated by the Research Flight Facility of the Environmental Science Services Administration was used during a thunderstorm research project at Flagstaff, Ariz., in July 1967. The aircraft was struck by lightning on three occasions, each case resulting in some minor structural damage.

The aircraft, a DC-6, is a well-equipped airborne system capable of measuring and recording most meteorological and electrical parameters. Three radar systems are used: an X-band height-finding radar, a forward-scanning C-band system, and a belly-mounted 360° S-band system.

Electric field meters designed by Kasemir [5] were installed on the nose and beneath the aircraft with the nose instrument measuring the vertical and the wing axis field components, and the belly instrument measuring the wing axis and line of flight electric field components. The field meters were installed and calibrated so that charging of the aircraft did not affect the measurement (Kasemir [6]).

Lightning strikes to aircraft are not unusual; however, relatively few instances have been documented with concurrent electric field and meteorological measurements (Gunn [2], Fitzgerald [1]). It seems important that such events should be reported.

2. OBSERVATIONS

Eighteen flights were made between July 11 and July 25. Thunderstorm penetrations were made on nine flights and usually repeated several times through the same cell.

The first two strikes occurred in the same storm cell, the first striking the nose boom on which the forward field mill was mounted, and the second striking a temperature instrument probe on the starboard wingtip. The third stroke, several days later, struck and severed an antenna overhead the forward cabin.

The information available at the time of the three lightning strokes is shown in table 1. The first and second strikes to the aircraft occurred on successive penetrations through the same cloud on July 15, 1967. This cloud, a dissipating cumulonimbus, was approximately 7 km. in diameter and produced considerable rain and hail along a narrow 50-km.-long path across the Arizona desert. The third lightning strike occurred on July 24, 1967, also in a dissipating, but much larger cloud, on a flight path only slightly within the cloud boundary. Height and size of the July 15 storm were visually estimated from the aircraft since the radar equipment was not operating. The July 24 storm was more accurately surveyed by three on-board radar systems.

3. DISCUSSION

Meteorological conditions were quite similar for the three lightning occurrences, as shown in table 1. In each case the aircraft was struck within the cloud, near the freezing level, and in each case both rain and graupel were encountered. Corona discharge was audibly detected on the aircraft communications system for about 2 sec. prior to each lightning strike to the aircraft, but did not recur as the aircraft increased its distance from the areas of highest electric fields.

The vertical and horizontal components of the electric field have been established as follows: The horizontal field components, E_x and E_y, are fixed with E_x parallel to the axis of the wings and E_y parallel to the line of flight and with the positive polarity directed toward the right and ahead of the line of flight respectively. The positive vertical field component, E_z, is directed upwards.

TABLE 1.—*Summary of three lightning strike events*

		No. 1	No. 2	No. 3
Electric Field, E_x	before discharge	+30 V.cm.$^{-1}$	0 V.cm.$^{-1}$	−40 V.cm.$^{-1}$
	after discharge	+10	+2	+25
Electric Field, E_y	before discharge	−15	0	0
	after discharge	0	0	+40
Electric Field, E_z	before discharge	−160	−40	−270
	after discharge	−50	+75	+230
Resultant Field Before Lightning $\sqrt{E_x^2+E_y^2+E_z^2}$		163	40	272
Flight Altitude (MSL)		4,870 m	4,870 m.	5,340 m.
Air Temperature		0° C.	0° C.	−2° C.
Diameter of Major Storm Cell		7 km.	7 km.	12 km.
Height of Storm (MSL)		9,000 m. (est)	9,000 m (est)	14,800 m. by radar
Aircraft Height Above Cloud Base		1,200 m.	1,200 m.	1,800 m.
Precipitation		Light Rain and Graupel	Heavy Rain and Graupel	Heavy Rain and Graupel
Turbulence		Light	Severe	Moderate
Damage to Aircraft		Small hole burned through field meter nose boom mount	Pin hole and burned spot on wingtip probe	Overhead antenna severed − 12 ga. wire ends curled and partially melted − Crew felt electrical shock
Remarks		Entering edge of small Cb. − Audible corona	In strong downdraft − Audible corona	Radar echo centered 8 km.to the west − Audible corona

Prior to each lightning strike event, the vertical field strength component was predominant and, as shown in table 1 the horizontal components did not contribute significantly to the resultant field vector at the aircraft.

The vertical fields reported here for aircraft lightning strike events are five to 10 times less than those reported by Gunn [2] and Fitzgerald [1] indicating that high fields are not a necessary ingredient to such occurrences. The vertical field at the time of the second lightning strike to the aircraft was only 40 v. cm.$^{-1}$ negative and the horizontal field components were negligible.

The storm of July 24 was more fully documented than the first. The ESSA DC-6 aircraft was flying a slowly ascending square pattern, 16 km. on each leg, from cloud base to 6 km. The flight path was mostly within the cloud boundary. At the same time a C-47 aircraft, also measuring electric fields, was flying repeated penetrations through the precipitation area below the cloud base. The C-47 was in the precipitation and an area of positive charge when the DC-6, above and in an area of negative charge, was struck by lightning. A vertical field change of the same polarity and approximately half the magnitude of that measured on the higher flying aircraft was recorded on the C-47 for the lightning event.

It is interesting to note that the vertical field component, E_z, for the third lightning strike event reversed its sign from before discharge to after discharge, yielding an opposite and almost equal absolute value (change from −270 to +230 v. cm.$^{-1}$). One might think this would lead to a subsequent lightning stroke with an opposite flow of current. The recorder chart reveals, however, that the vertical electric field decreased steadily from +230 v. cm.$^{-1}$, crossed zero value and increased negatively with no further discharges being recorded from the same storm cell for several minutes.

It has been suggested by L. P. Harrison [3] and by H. T. Harrison [4] that an aircraft might under some conditions act to initiate a lightning discharge. Fitzgerald [1] has reported more than 30 instances of lightning discharges to an instrumented F-100 aircraft in Florida thunderstorms. He concludes, on the basis of considerable evidence, that an aircraft entering a storm in an early stage of dissipation, may act to "trigger" a lightning discharge. The data reported here would appear to agree with the above conclusion.

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